Color flows for the process $gg \to B_c + c + \bar{b}$

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The contributions of different color flows into the gluonic B_c-meson production cross section has been calculated. This study is essential to simulate B_c-meson production with the help of Pythia program. The essence of matter is that in the frame work of the Lund model used by Pythia the hadronization way of the final partons and hadronic remnants depends on color flow type. The modified method for calculation of the color flow contributions has been proposed.

1. INTRODUCTION

A simulation of particle production processes at modern hadronic experiments is practically impossible without Monte-Calro methods. The fact of the matter is that the integro-differential equations, which are used to describe the evolution of initial partons and the hadronization of parton interaction products, are very complicated. Recent time PYTHIA [1] is the most dependable program for Monte-Carlo simulation of a particle production at high energies. This software simulate all three studies, on which the hadronic production can be conventionally subdivided: the initial parton evolution, the hard subprocess of the initial partonic interaction, the hadronization of the hard interaction products and hadronic remnants. The hard subprocess is calculated in the frame work of perturbative QCD. The hadronization in Phythia is described by Lund model [2]. In the frame work of this model one supposes that outgoing color charges stretch the connecting force fields (color strings), and it is these fields that eventually break up to produce the final state hadrons. The force field is always stretched from a color triplet to a color antitriplet. Color octets (for example, gluons) are treated as an excitation of the string. A technique which allows to calculate the particular color flow contribution into the cross section has been performed in [2]. Also it has been demonstrated in [2] that at infinite color number limit $N_c \to \infty$ the interference terms between different color flows equal to zero.

A wide set of standard hard processes can be simulated by PYTHIA, however this set does

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not contain all processes, which would be interesting to study at high energies. That is why in the recent versions of PYTHIA a user have a possibility to include his own matrix element into the PYHTIA program. Therefore the problem of color flow separation appears. It is important to know the contribution of different color flows into the cross section, because each color flow corresponds to its sole hadronization way.

In this work the color flows for the process of gluonic production of B_c-meson have been studied. The modified calculation method of the color flow contributions has been proposed, which is slightly differ from the traditional one.

It is worth to note that it is somewhat difficult to calculate the cross section for the process of gluonic B_c-meson production, because B_c-meson production mechanism can not be treated as $b\bar{b}$-pair production followed by b-quark hadronization into B_c-meson. Therefore B_c-meson production can not be described by the fragmentation function $b \to B_c$ (the fragmentation function calculations have been performed in [3]). It has been shown that under conditions of present-day and planed experiments the recombination mechanism of B_c-mesons production dominates. To estimate the recombination contribution into the cross section one need to calculate 36 tree-level Feynman diagrams of order $O(\alpha_s^4)$. These calculations have been done independently by several research groups [4–9]. The results of [4–7] are in a good agreement with each other.

An interest in B_c-meson production in hadronic interactions is increasing now due to the fact that LHC will have started to work in the nearest future. The last versions of PHYTIA based generator SIMUB [10] include the useful subroutines to simulate B_c production, which are based on codes of research groups [4, 5]. The fruitful scientific contacts between the author and SIMUB developers have caused the presented study.

2. THE SEPARATION OF COLOR FLOWS

The Feynman diagrams for the process $gg \to B_c + X$ are shown in Fig. 1. It is useful to treat the diagram with four gluonic vertex as three different diagrams, because that diagram contains three different color structure. The color parts of the diagrams are given by following equations:

$$T_1 = f^{n_1 g_2 n_2} f^{n_3 n_2 g_1} t^{n_1}_{c\bar{c}} t^{n_3}_{b\bar{b}} \delta_{b\bar{c}},$$

$$T_2 = f^{n_1 g_2 n_2} f^{n_3 n_2 g_1} t^{n_3}_{c\bar{c}} t^{n_1}_{b\bar{b}} \delta_{b\bar{c}},$$

$$T_3 = f^{n_1 g_1 g_2} f^{n_2 n_1 n_3} t^{n_2}_{b\bar{b}} t^{n_3}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_4 = f^{n_1 g_2 n_2} f^{n_2 n_3 g_1} t^{n_3}_{b\bar{b}} t^{n_1}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_5 = f^{g_2 n_1 n_2} f^{n_2 n_3 g_1} t^{n_1}_{b\bar{b}} t^{n_3}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_6 = f^{n_1 n_2 n_3} f^{n_3 g_2 g_1} t^{n_1}_{b\bar{b}} t^{n_2}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_7 = i f^{n_1 n_2 g_2} t^{n_1}_{c\bar{c}} t^{g_1}_{b l_1} t^{n_2}_{l_1 \bar{b}} \delta_{b\bar{c}},$$

$$T_8 = i f^{n_1 n_2 g_2} t^{n_1}_{c\bar{c}} t^{n_2}_{b l_1} t^{g_1}_{l_1 \bar{b}} \delta_{b\bar{c}},$$

$$T_9 = i f^{n_1 n_2 g_2} t^{n_1}_{b\bar{b}} t^{g_1}_{c l_1} t^{n_2}_{l_1 \bar{c}} \delta_{b\bar{c}},$$

$$T_{10} = i f^{n_1 n_2 g_2} t^{n_1}_{b\bar{b}} t^{n_2}_{c l_1} t^{g_1}_{l_1 \bar{c}} \delta_{b\bar{c}},$$

$$T_{11} = i f^{n_1 n_2 g_1} t^{n_1}_{b\bar{b}} t^{n_2}_{c l_1} t^{g_2}_{l_1 \bar{c}} \delta_{b\bar{c}},$$

$$T_{12} = i f^{n_1 n_2 g_1} t^{n_1}_{b\bar{b}} t^{g_2}_{c l_1} t^{n_2}_{l_1 \bar{c}} \delta_{b\bar{c}},$$

$$T_{13} = i f^{n_1 n_2 g_1} t^{n_1}_{c\bar{c}} t^{n_2}_{b l_1} t^{g_2}_{l_1 \bar{b}} \delta_{b\bar{c}},$$

$$T_{14} = i f^{n_1 n_2 g_1} t^{n_1}_{c\bar{c}} t^{g_2}_{b l_1} t^{n_2}_{l_1 \bar{b}} \delta_{b\bar{c}},$$

$$T_{15} = t^{g_1}_{b l_1} t^{n_1}_{l_1 \bar{b}} t^{n_1}_{c l_2} t^{g_2}_{l_2 \bar{c}} \delta_{b\bar{c}},$$

$$T_{16} = t^{n_1}_{b l_1} t^{g_1}_{l_1 \bar{b}} t^{n_1}_{c l_2} t^{g_2}_{l_2 \bar{c}} \delta_{b\bar{c}},$$

$$T_{17} = t^{g_1}_{b l_1} t^{n_1}_{l_1 \bar{b}} t^{g_2}_{c l_2} t^{n_1}_{l_2 \bar{c}} \delta_{b\bar{c}},$$

$$T_{18} = t^{g_1}_{b l_1} t^{n_1}_{l_1 \bar{b}} t^{g_2}_{c l_2} t^{n_1}_{l_2 \bar{c}} \delta_{b\bar{c}},$$

$$T_{19} = t^{n_1}_{b l_1} t^{g_2}_{l_1 \bar{b}} t^{g_1}_{c l_2} t^{n_1}_{l_2 \bar{c}} \delta_{b\bar{c}},$$

$$T_{20} = t^{n_1}_{b l_1} t^{g_2}_{l_1 \bar{b}} t^{n_1}_{c l_2} t^{g_1}_{l_2 \bar{c}} \delta_{b\bar{c}},$$

$$T_{21} = t^{n_1}_{b l_1} t^{g_2}_{l_1 \bar{b}} t^{n_1}_{c l_2} t^{g_1}_{l_2 \bar{c}} \delta_{b\bar{c}},$$

$$T_{22} = t^{g_2}_{b l_1} t^{n_1}_{l_1 \bar{b}} t^{n_1}_{c l_2} t^{g_1}_{l_2 \bar{c}} \delta_{b\bar{c}},$$

$$T_{23} = t^{n_1}_{b l_1} t^{g_1}_{l_1 l_2} t^{g_2}_{l_2 \bar{b}} t^{n_1}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_{24} = t^{g_1}_{b l_1} t^{n_1}_{l_1 l_2} t^{g_2}_{l_2 \bar{b}} t^{n_1}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_{25} = t^{g_1}_{b l_1} t^{g_2}_{l_1 l_2} t^{n_1}_{l_2 \bar{b}} t^{n_1}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_{26} = t^{n_1}_{b l_1} t^{g_2}_{l_1 l_2} t^{g_1}_{l_2 \bar{b}} t^{n_1}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_{27} = t^{g_2}_{b l_1} t^{n_1}_{l_1 l_2} t^{g_1}_{l_2 \bar{b}} t^{n_1}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_{28} = t^{g_2}_{b l_1} t^{g_1}_{l_1 l_2} t^{n_1}_{l_2 \bar{b}} t^{n_1}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_{29} = t^{n_1}_{cl_1} t^{g_1}_{l_1 l_2} t^{g_2}_{l_2 \bar{c}} t^{n_1}_{b\bar{b}} \delta_{b\bar{c}},$$

$$T_{30} = t^{g_1}_{cl_1} t^{n_1}_{l_1 l_2} t^{g_2}_{l_2 \bar{c}} t^{n_1}_{b\bar{b}} \delta_{b\bar{c}},$$

$$T_{31} = t^{g_1}_{cl_1} t^{g_2}_{l_1 l_2} t^{n_1}_{l_2 \bar{c}} t^{n_1}_{b\bar{b}} \delta_{b\bar{c}},$$

$$T_{32} = t^{n_1}_{cl_1} t^{g_2}_{l_1 l_2} t^{g_1}_{l_2 \bar{c}} t^{n_1}_{b\bar{b}} \delta_{b\bar{c}},$$

$$T_{33} = t^{g_2}_{cl_1} t^{n_1}_{l_1 l_2} t^{g_1}_{l_2 \bar{c}} t^{n_1}_{b\bar{b}} \delta_{b\bar{c}},$$

$$T_{34} = t^{g_2}_{cl_1} t^{g_1}_{l_1 l_2} t^{n_1}_{l_2 \bar{c}} t^{n_1}_{b\bar{b}} \delta_{b\bar{c}},$$

$$T_{35} = i f^{n_1 g_1 g_2} t^{n_2}_{bl_1} t^{n_1}_{l_1 \bar{b}} t^{n_2}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_{36} = i f^{n_1 g_1 g_2} t^{n_1}_{bl_1} t^{n_2}_{l_1 \bar{b}} t^{n_2}_{c\bar{c}} \delta_{b\bar{c}},$$

$$T_{37} = i f^{n_1 g_1 g_2} t^{n_2}_{cl_1} t^{n_1}_{l_1 \bar{c}} t^{n_2}_{b\bar{b}} \delta_{b\bar{c}},$$

$$T_{38} = i f^{n_1 g_1 g_2} t^{n_1}_{cl_1} t^{n_2}_{l_1 \bar{c}} t^{n_2}_{b\bar{b}} \delta_{b\bar{c}},$$

where upper indexes g_1, g_2 are color states of the initial gluons, lower indexes b, $\bar{b}$, c, $\bar{c}$ are color states of b-, $\bar{b}$-, c-, $\bar{c}$-quarks correspondingly and $\delta_{b\bar{c}}$ is a color wave function of the B_c-meson (the normalization coefficient $1/\sqrt{3}$ is not written for the sake of simplicity).

Let us study, for example, the color part of diagram 1 (see Fig. 1. In this diagram the initial guons exchange a gluon in t-channel and split into the quark-antiquark pairs):

$$T_1 = f^{n_1 g_2 n_2} f^{n_3 n_2 g_1} t^{n_1}_{c\bar{c}} t^{n_3}_{b\bar{b}} \delta_{b\bar{c}} = f^{n_1 g_2 n_2} f^{n_3 n_2 g_1} (t^{n_1} t^{n_3})_{\bar{b}c}.$$

Using the identity $t^a t^b - t^b t^a = i f^{abc} t^c$, one can found:

$$f^{n_1 g_2 n_2} f^{n_3 n_2 g_1} t^{n_1} t^{n_3} = -(t^{g_2} t^{n_2} - t^{n_2} t^{g_2})(t^{n_2} t^{g_1} - t^{g_1} t^{n_1}) =$$

$$= -t^{g_2} t^{n_2} t^{n_2} t^{g_1} + t^{n_2} t^{g_2} t^{n_2} t^{g_1} + t^{g_2} t^{n_2} t^{g_1} t^{n_1} - t^{n_2} t^{g_2} t^{g_1} t^{n_1} =$$

$$-\frac{4}{3} t^{g_2} t^{g_1} - \frac{1}{6} t^{g_2} t^{g_1} - \frac{1}{6} t^{g_2} t^{g_1} - (\frac{1}{4} \delta^{g_1 g_2} - \frac{1}{6} t^{g_2} t^{g_1}) =$$

$$= -\frac{1}{4} \delta^{g_1 g_2} - \frac{3}{2} t^{g_2} t^{g_1}.$$

Thus:

$$T_1 = -\frac{3}{2} t^{g_2}_{ck} t^{g_1}_{k\bar{b}} - \frac{1}{4}\delta^{g_1 g_2}\delta_{c\bar{b}}.$$

The first term (see the scheme (2) in Fig. 2) corresponds to the case, where a color of the second gluon (g_2 flows to c-quark, an anticolor of the first gluon (g_1) flows to $\bar{b}$-quark, and a color of the first gluon annihilates with an anticolor of the second gluon (sum over k). The second term corresponds to the case, where colors and anticolors of the initial gluons annihilate, and a color and an anticolor of c-quark and $\bar{b}$-quark are produced from a vacuum (see the scheme (3) in Fig. 2). In addition to the terms described above, the term $t^{g_1}_{ck} t^{g_2}_{k\bar{b}}$ contributes to another diagrams. The latter one corresponds to the case, where a color of the first gluon (g_1 flows to c-quark, an anticolor of the second gluon (g_2) flows to $\bar{b}$-quark, and an anticolor of the first gluon annihilates with an color of the second gluon (see the scheme (1) in Fig. 2). There are no color flows for discussed process but such as three ones described above. This color flow separation has been done by following the recipe given in papers [2].

Nevertheless, it would be better to base on more fundamental QCD principles to describe color flows. Let us consider the term $\delta^{g_1 g_2}\delta_{c\bar{b}}$, which corresponds to the production of c-quark and $\bar{b}$-quark in a color singlet. Naturally, a color sting stretch between these two quarks. It is worth to note that the term $t^{g_2}_{ck} t^{g_1}_{k\bar{b}}$ contains the singlet part too:

$$t^a t^b = \frac{1}{6}\delta^{ab} + \frac{1}{2}(d^{abc} + i f^{abc}) t^c. \tag{1}$$

Therefore "one part" of the singlet is hadronized in one manner, and "other part" of the singlet is hadronized in other manner. We think that it would be better to treat the total color singlet contribution as the separate color flow. Two other color flows would be composed of two color octet states d and f.

That is why we redefine the color flows as follows:

1. A color of the first gluon flows to c-quark, an anticolor of the second gluon flows to $\bar{b}$-quark, an anticolor of the first gluon and a color of the second one annihilate:

$$\frac{1}{2}(d^{g_1 g_2 k} + i f^{g_1 g_2 k}) t^k_{c\bar{b}}.$$

2. A color of the second gluon flows to c-quark, an anticolor of the first gluon flows to $\bar{b}$-quark, a color of the first gluon and an anticolor of the second one annihilate:

$$\frac{1}{2}(d^{g_1 g_2 k} - i f^{g_1 g_2 k}) t^k_{c\bar{b}}.$$

3. A color and an anticolor of the initial gluons annihilate, a color of c-quark and an anticolor of $\bar{b}$-quark are produced from vacuum:

$$\delta^{g_1 g_2}\delta_{c\bar{b}}.$$

In our point of view these definitions of colors flows are more physically justified, because the singlet state contribution is separated from the octet contributions and there is no an interference term between the singlet color flow and other flows.

The definitions described above slightly differ from the traditional ones: $t^{g_1}_{ck}t^{g_2}_{k\bar{b}}$, $t^{g_2}_{ck}t^{g_1}_{k\bar{b}}$ and $\delta^{g_1 g_2}\delta_{c\bar{b}}$. However, an accuracy of the color flow separation is about $1/N_c$, where N_c is a color number. For an arbitrary N_c the equation (1) looks like follows:

$$t^a t^b = \frac{1}{2N_c}\delta^{ab} + \frac{1}{2}(d^{abc} + if^{abc})t^c, \tag{2}$$

and one can conclude that at $1/N_c \to \infty$, the both definition sets lead to the same results.

Thus the color part of matrix element n can be given by the following expression:

$$T_n = \frac{1}{2}(d^{g_1 g_2 k} + if^{g_1 g_2 k})t^k_{c\bar{b}} \cdot A_n + \frac{1}{2}(d^{g_1 g_2 k} - if^{g_1 g_2 k})t^k_{c\bar{b}} \cdot B_n + \delta^{g_1 g_2}\delta_{c\bar{b}} \cdot C_n, \tag{3}$$

From (3) one can easy obtain the color matrix averaged over the initial color states and summed over the final ones:

$$M_{mn} = \frac{1}{64}\Big((D+F)\cdot A_m A_n + (D+F)\cdot B_m B_n + (D-F)\cdot(A_m B_n + B_m A_n) + S\cdot C_m C_n\Big), \tag{4}$$

where $D = 5/3$, $F = 3$, and $S = 24$. Vectors A_n, B_n and C_n are performed at the table 1.

In our approach the color matrix corresponded with an interference between the color flows $(d^{g_1 g_2 k} + if^{g_1 g_2 k})t^k_{c\bar{b}}$ and $(d^{g_1 g_2 k} - if^{g_1 g_2 k})t^k_{c\bar{b}}$ have a simple form:

$$M^{\rm int}_{mn} = \frac{1}{64}\Big((D-F)\cdot(A_m B_n + B_m A_n)\Big) \tag{5}$$

It is worth to note, that the formula (3) can be easily rewritten in the traditional color flow definitions:

$$T_n = t^{g_1}_{ck}t^{g_2}_{k\bar{b}} \cdot A_n + t^{g_2}_{ck}t^{g_1}_{k\bar{b}} \cdot B_n + \delta^{g_1 g_2}\delta_{c\bar{b}} \cdot (C_n - \frac{A_n + B_n}{6}). \tag{6}$$

One can see that the expressions for the color flow (1) given by (3) and (6) differ from each other only in a common coefficient. It is easily to show that for the color flow (1) the ratio for the matrix element from (3) to one from (6) is 7 : 8, as well as for (2).

3. CALCULATION RESULTS

The cross section distributions over exit angles of final particles (B_c, $\bar{b}$ and c) have been shown in Fig. 3 and 4 for the different color flows and for the interference term at the gluon interaction energy 25 GeV. This energy value has been chosen because it is common value for B_c-meson production at LHC. It is worth to mention that intuitive ideas about color flows correspond to the calculation results. Indeed, it is clear from Fig. 3c and 4c that $\bar{b}$-quark moves mainly in the direction of gluon, which transfer an anticolor to $\bar{b}$-quark, Also one can see from Fig. 3f and 4f, that c-quark moves mainly in the direction of gluon, which transfer a color to c-quark. It is not unexpected, that the color flow (3), which corresponds to a singlet state, is symmetrically distributed over the angles.

The interference term between flows (1) and (2) is small (see Fig. 3b, d, f Й 4b, d, f). For the pseudoscalar B_c-meson production at 25 GeV the interference contribution is negative for all values of the exit angles. For the vector meson production the interference contribution is negative too with the exception of peripheral regions of the angular distributions. The total interference contribution into the vector meson production is negative, as well as into the pseudoscalar meson production. Our calculations show that at low energies the interference contribution becomes positive for the vector meson production and remains negative for the pseudoscalar meson production. An absolute value of the interference contribution is small at all interaction energies.

As it was mentioned above, the contributions of the color flows (1) and (2) in our separation scheme differ from the traditionally determined contributions only by the common coefficient. It is not so for the color flow (3). The contribution of (3) in our approach one in traditional approach differs from each other in shape too. The distributions over exit angle of B_c-meson in the frame work of traditional and our approaches have been presented in Fig. 5. One can see that in our approach the contribution of (3) is larger than this contribution in the traditional scheme. The point is that in our approach there is no interference between the color flows (1) and (3), as well as between (2) and (3). Therefore the contributions, which correspond in traditional scheme to the interference between (1) and (3), as well as between (2) and (3), transfer to color flow (3).

4. CONCLUSIONS

The proposed calculation method minimize interference terms between color flows for the process $gg \to B_c + \bar{b} + c \to B_c + X$. That is why interference terms can be neglected in our approach.

Furthermore the method under discussion allows us to ascertain more clearly how color states of final partons correspond with color flows. The redistribution of interference terms leads to the amplification of the color flow (3). The contribution of this color flow into the central kinematic region becomes comparable with the contributions of color flows (1) and (2). Thus haronization features of the outgoing partons $\bar{b}$ and c could be changed.

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Table 1. The vectors A_n , B_n, C_n corresponded with the color flows (1), (2), (3) in Fig. 2.

n	A_n	B_n	C_n	n	A_n	B_n	C_n
1	0	−3/2	−1/2	20	−1/6	0	−1/36
2	−3/2	0	−1/2	21	−1/6	0	−1/36
3	3/2	-3/2	0	22	−1/6	0	2/9
4	0	3/2	1/2	23	4/3	0	2/9
5	−3/2	0	−1/2	24	−1/6	0	−1/36
6	3/2	−3/2	0	25	−1/6	0	2/9
7	0	0	1/4	26	0	4/3	2/9
8	0	-3/2	−1/4	27	0	−1/6	−1/36
9	3/2	0	1/4	28	0	−1/6	2/9
10	0	0	−1/4	29	−1/6	0	2/9
11	0	0	−1/4	30	−1/6	0	−1/36
12	0	3/2	1/4	31	4/3	0	2/9
13	−3/2	0	−1/4	32	0	−1/6	2/9
14	0	0	1/4	33	0	−1/6	−1/36
15	0	−1/6	2/9	34	0	4/3	2/9
16	0	−1/6	−1/36	35	4/3	−4/3	0
17	0	−1/6	−1/36	36	−1/6	1/6	0
18	0	4/3	2/9	37	−1/6	1/6	0
19	4/3	0	2/9	38	4/3	−4/3	0

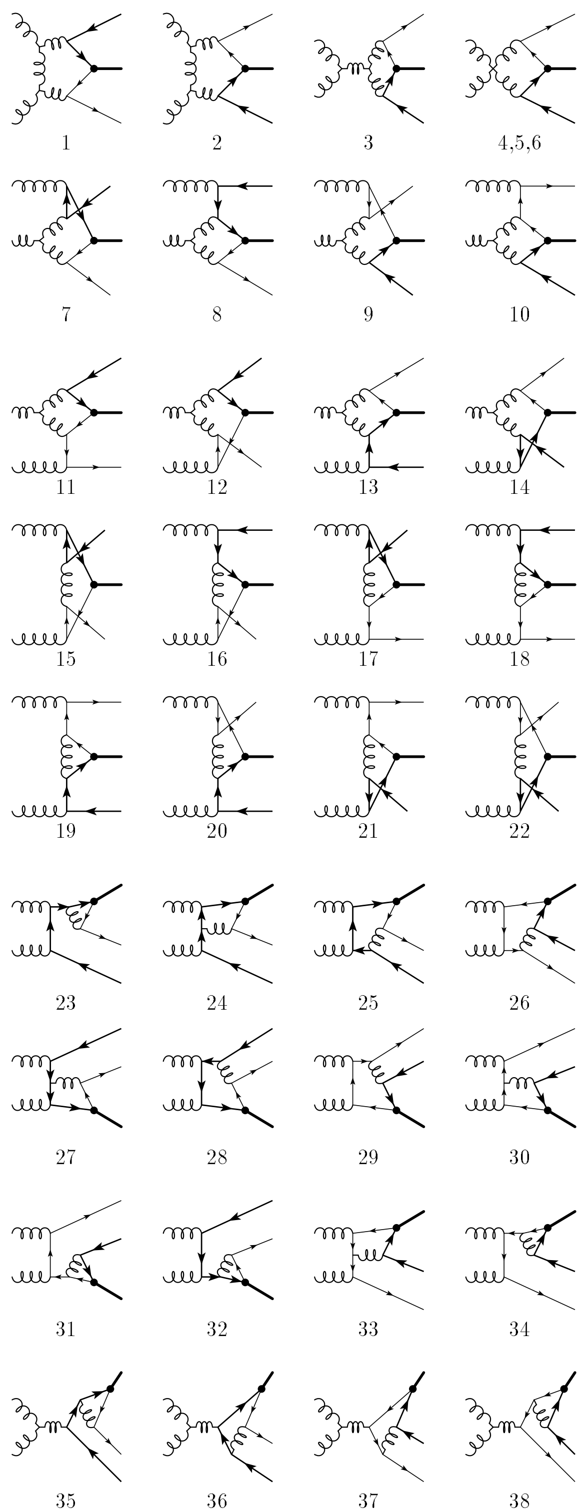

Figure 1. Feynman diagrams for B_c-meson production in the gluonic interaction.

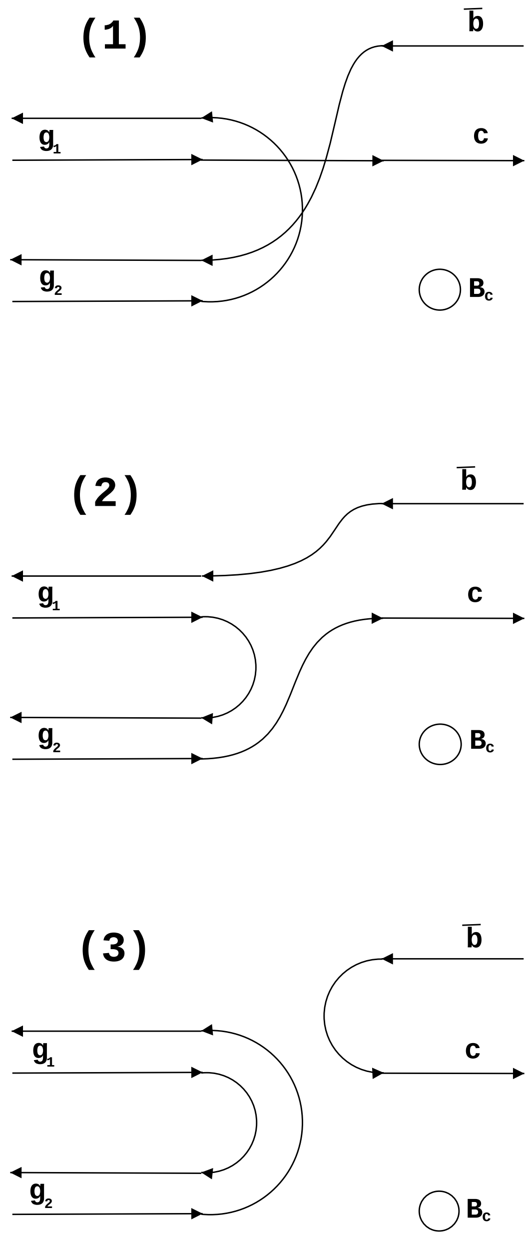

Figure 2. Color flows for the process $gg \to B_c + c + \bar{b}$. Color strings stretch as follows for the color flow (1): [c-quark $\longrightarrow$ the remnant of hadron, which contained the gluon g_1 $\longrightarrow$ the remnant of hadron, which contained the gluon g_2 $\longrightarrow$ $\bar{b}$-quark]; for the color flow (2): [c-quark $\longrightarrow$ the remnant of hadron, which contained the gluon g_2 $\longrightarrow$ the remnant of hadron, which contained the gluon g_1 $\longrightarrow$ $\bar{b}$-quark]; for the color flow (3): [c-quark $\longrightarrow$ $\bar{b}$-quark], [the remnant of hadron, which contained the gluon g_1 $\rightleftarrows$ the remnant of hadron, which contained the gluon g_2].

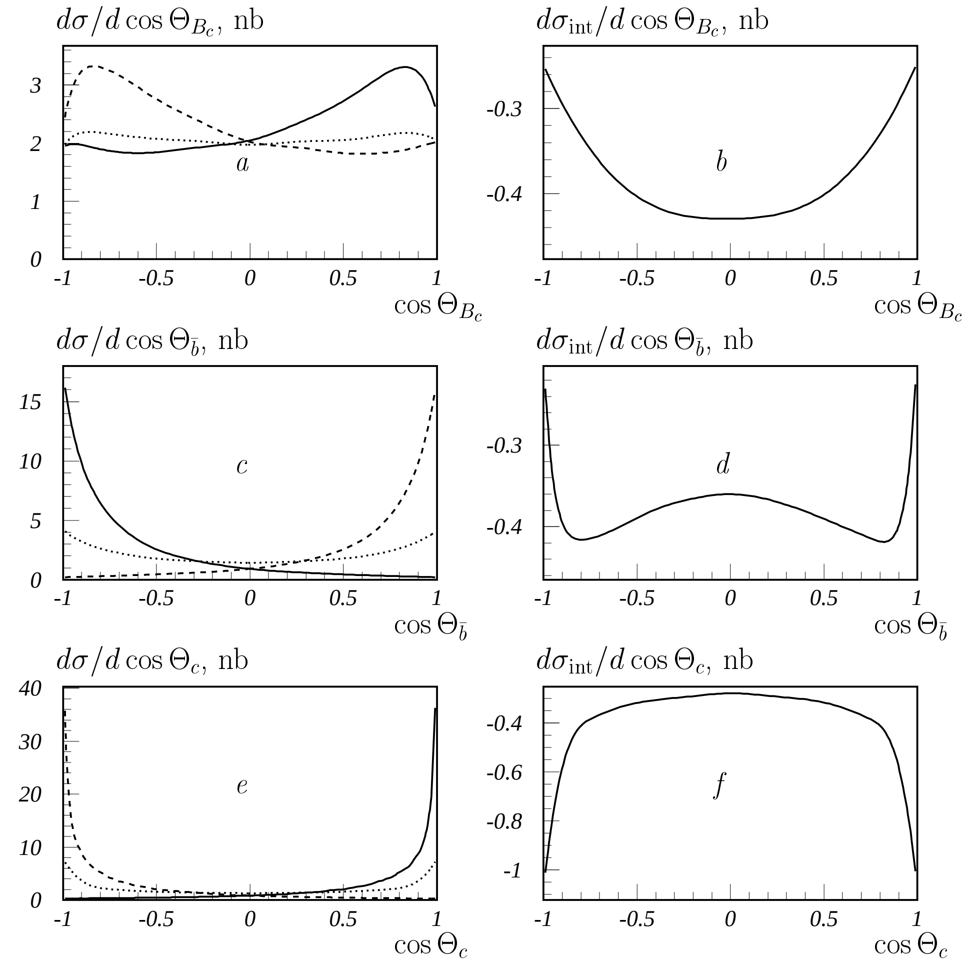

Figure 3. The cross section distributions for the pseudoscalar B_c-meson production at 25 GeV ($gg \to B_c + \bar{b} + c$) for the different color flows and the interference term: over the exit angle of B_c-meson (a) and b)); over the exit angle of $\bar{b}$-quark (c) and d)); over the exit angle of c-quark (e) and f)). A solid curve in plots a), c) and e) denotes the color flow (1); a dashed curve denotes the color flow (2); a dotted one denotes the color flow (3). The interference contribution is shown in plots b), d) and f).

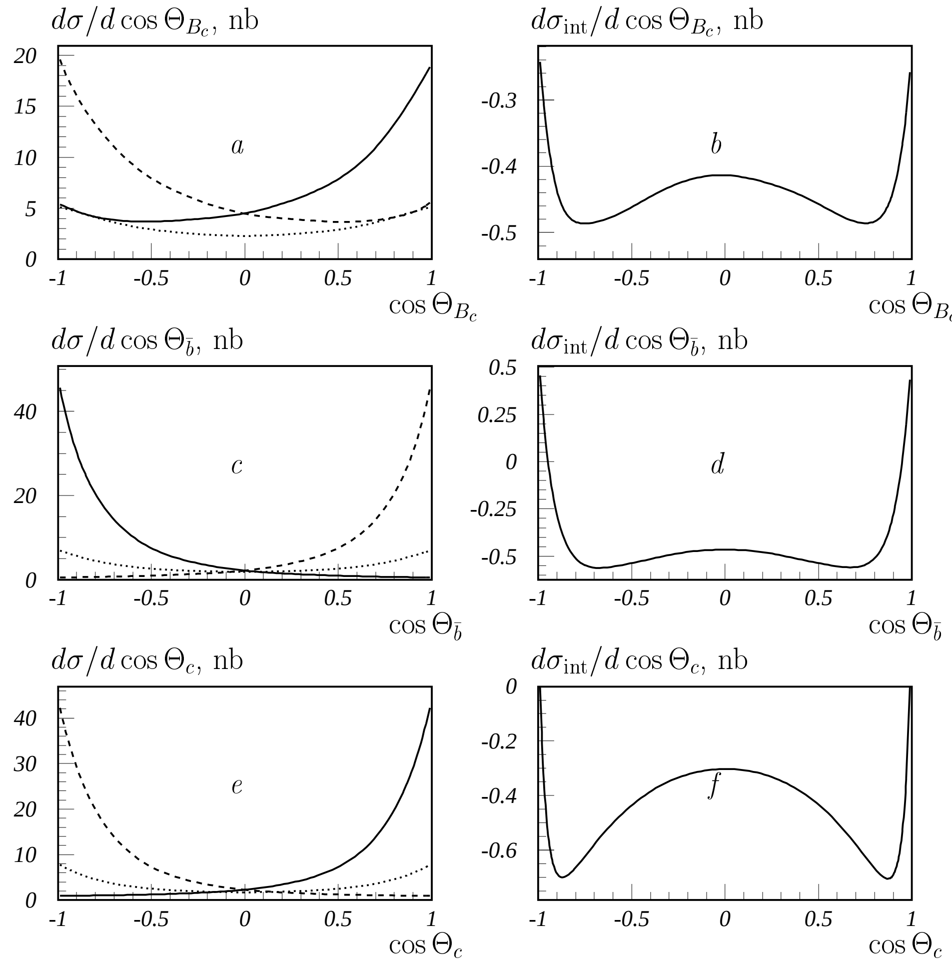

Figure 4. The cross section distributions for the vector B_c-meson production at 25 GeV for the different color flows and the interference term. The designations are the same as in Fig. 3.

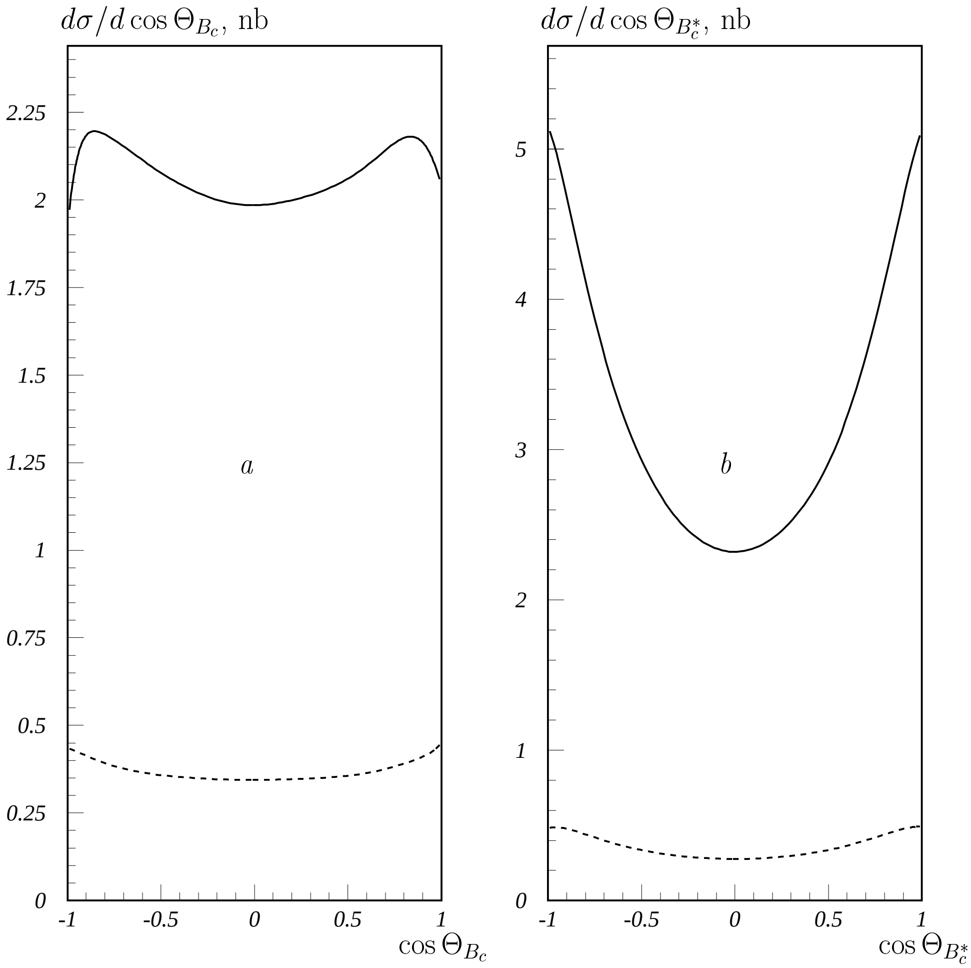

Figure 5. The cross section distributions over the exit angle of pseudoscalar (a) and vector (b) B_c-meson for the color flow (3): in our approach (solid curve) and in the traditional one (dashed curve).